CHAPTER

7

STORAGE MANAGEMENT

After reading this chapter and completing the exercises, you will be able to:

- Create and manage basic and dynamic disks using Windows 2000 disk management tools
- Understand and create the different Windows 2000 volumes, including simple, spanned, striped, mirrored, and RAID 5 volumes
- Recover from failed mirrored and RAID 5 volumes in Windows 2000
- Assign quotas for all users and for individual users
- Upgrade a basic disk to become a dynamic disk
- Extend an NTFS volume to include extra disk space

Storage management is a key ingredient in maintaining an operating system. Before you can install any operating system, however, you must create a partition. The operating system will then install its files in this partition (or partitions). Windows 2000 is capable of creating and managing two different types of storage disks: basic and dynamic.

A basic disk uses single partitions with no fault tolerance or increased efficiency. This type of partition is similar to the partitions used in previous versions of Windows, such as Windows 95/98 and Windows NT 4.0, and DOS. A dynamic disk is a new type of storage disk available with Windows 2000. Unlike basic disks, dynamic disks are not limited to the number of partitions that can be created on them.

ORGANIZING DISK SPACE

Before you can efficiently organize and manage your disk space, you need to understand some of the differences between and features of basic and dynamic disks. It is also important that you become familiar with the Windows 2000 tools that are used to maintain and configure your disks.

When configuring disks in Windows NT 4.0, the Disk Administrator tool was used. This tool no longer exists in its original form in Windows 2000; it has been replaced by the Disk Management tool.

Like many of the administration tools that ship with Windows 2000, the Disk Management tool is simply a Microsoft Management Console (MMC) snap-in. You can either create a custom MMC interface or use the default interface that is available under the Computer Management administration tool. This tool is found under the Administration Tools Start menu option, Computer Management, and is shown in Figure 7-1.

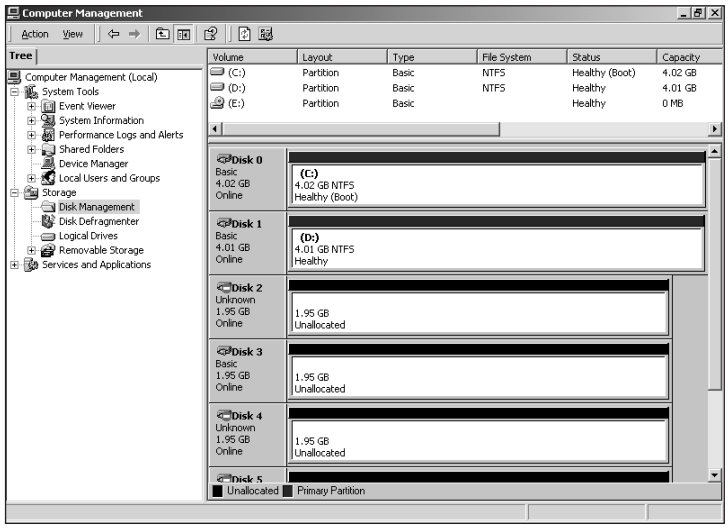

Figure 7-1 Computer Management Administration tool, with Disk Management selected

The next sections discuss the creation and management of basic disks, followed by the creation and management of Windows 2000 dynamic disks.

Basic Disks

If you know how to create and manage disks and partitions in Windows NT 4.0, then you are aware of basic disks. **Basic disks** are simply defined as disks that are compatible with Windows NT 4.0 and earlier Windows operating systems (such as Windows 95/98). When you add a new hard disk to your system, it is first created as a basic disk. You have the option to upgrade it to a dynamic disk later.

A disk can be either basic or dynamic, but not both. You cannot have a single disk that uses both types of storage.

Before Windows 2000 can recognize a new hard disk, it must write a signature to it. Windows 2000 automatically detects any new disks and launches the Write Signature and Upgrade Disk Wizard to write a signature to it. This wizard is shown in Figure 7-2. Any disks that Windows 2000 has not signed yet are listed as unknown (see Figure 7-1). To write a signature to one of these unknown disks, simply right-click the drive and choose the Write Signature option.

Figure 7-2 Write Signature and Upgrade Disk Wizard

Basic disk drives can have two types of partitions: primary and extended. There is a limit of four partitions on a single physical disk. A primary partition is assigned a drive letter (such as C: or D:), whereas an extended partition can have multiple logical drives created within it. See Figure 7-3.

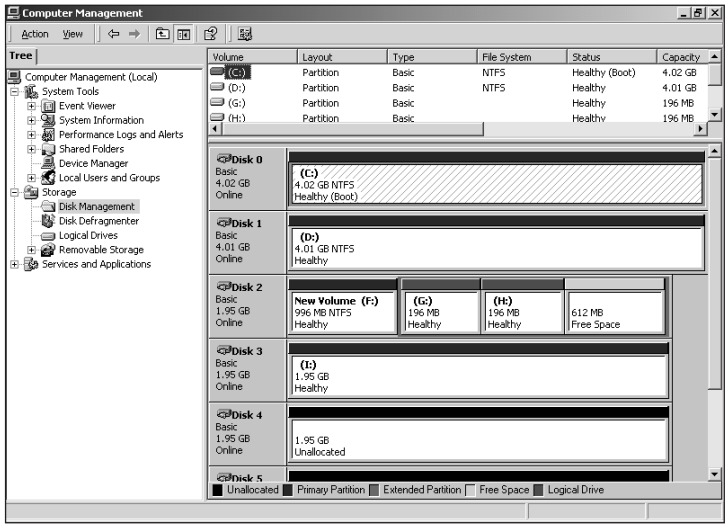

Figure 7-3 A basic disk

In addition to primary and extended partitions, basic disks can contain four types of volumes. Table 7-1 lists the types of volumes with both their Windows NT 4.0 and Windows 2000 names.

Table 7-1 Volume types in Windows NT 4.0 and Windows 2000

Windows NT 4.0	Windows 2000	Description
Volume set	Spanned volume	A way of using the space on different disks as a single volume
Mirror set	Mirrored volume	A way of storing information on two disks at the same time for fault-tolerance purposes
Stripe set	Striped volume	An efficient way of speeding up disk access by using multiple disks that act as a single disk
Stripe set with parity	RAID 5 volume	A fault-tolerant method of using multiple disks to store data

Dynamic Disks

A new feature of Windows 2000 is support for **dynamic disks**. As stated earlier, when new disks are added to your system, they are initially created as basic disks and can be later converted to dynamic disks. Dynamic disks offer some benefits over basic disks, including the following:

- An unlimited number of volumes can be created on a single disk.
- All disk configuration information (including partition sizes and types) is stored on the disk. This setup differs from Windows NT 4.0, where the disk configuration information is stored in the Registry. It allows a disk to be moved from one

system to another without the need to recreate any of the volumes. This convenience is especially notable with mirrored, spanned, or RAID 5 volumes.

- All disk configuration information is replicated to all other dynamic disks in the system. This configuration information can therefore be accessed even if a disk fails. Once the disk is replaced, Windows 2000 can then easily recreate the volume size and type from this configuration information.
- Volumes can be extended by including space available on other disks. The space used does not need to be contiguous. To be extended, a volume must exist on a dynamic disk and be formatted as an NTFS volume.

You can revert from a dynamic disk back to a basic disk only if you remove any volumes that have been created.

An NTFS volume on a basic disk that was upgraded to a dynamic disk cannot be extended. Only volumes created after a disk has been upgraded to a dynamic disk can be extended.

Although you can create an unlimited number of volumes on a single disk, dynamic disks support only five types of volumes:

- A simple volume
- A spanned volume
- A mirrored volume
- A striped volume
- A RAID 5 volume

Two of these volumes are fault-tolerant volumes (mirrored and RAID 5) and are covered in a later section. The remaining three volume types are discussed next.

Simple Volumes

A simple volume is defined as a volume that includes space on a single disk. At first glance, you might think that a simple volume is the same as a partition. There are, however, some distinctions of which you should be aware.

A simple volume does not have the same size restrictions that a partition on a basic disk does. This consideration is extremely important today, because 20 or 60 GB disks are not uncommon. You are also not limited to the number of volumes that you create on a single disk. For example, if you were to partition a 20 GB disk, you would be limited to a maximum of four partitions with only one extended partition. With dynamic disks and simple volumes, you could have as many volumes as needed.

Another advantage of simple volumes is that you can extend them at a later date. If you created a 3 GB simple volume on a 6 GB disk, and later saw that you were about to run out of disk space, you could extend the 3 GB simple volume to the full 6 GB of the disk. Be aware that you can extend the volume only so long as the extra 3 GB has not been allocated to another volume.

A simple volume can be formatted with one of the three file systems supported by Windows 2000: file allocation table (FAT), FAT32, and NTFS. Figure 7-4 shows a simple volume as it appears in the Computer Management administration tool. Hands-on Project 7-6 explains how to create a simple volume.

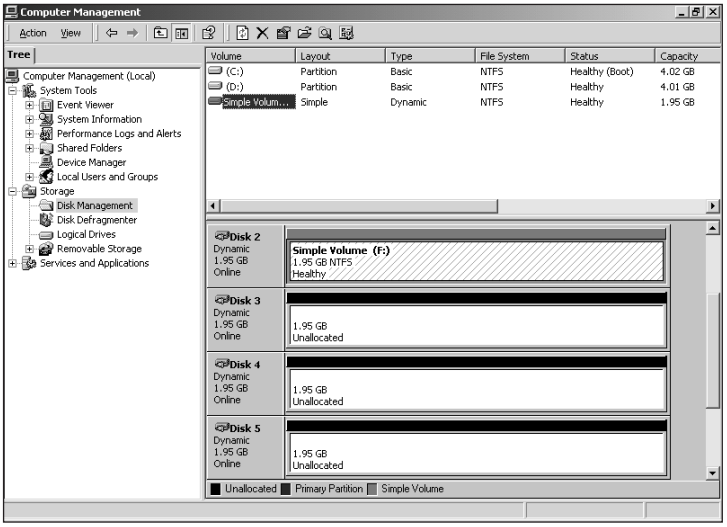

Figure 7-4 A simple volume

A simple volume may be extended only if it is formatted as an NTFS volume. To extend a FAT or FAT32 volume, you must first convert the volume to NTFS. To convert a FAT or FAT32 volume to NTFS, simply use the CONVERT command. Execute the command using the following format: Convert *driveletter* /FS:NTFS

Spanned Volumes

A spanned volume is a volume that includes space from two or more disks, up to a maximum of 32 disks. Spanned volumes do not give you any fault tolerance or performance improvement over a simple volume; they simply allow you to use space from multiple disks as a single logical disk.

The space on the spanned volume is used in the order that the disks were selected. If, for example, you were to use a 1.1 GB, a 2.0 GB, and a 3.2 GB disk to create a single spanned volume that is 6.3 GB in size, then the 2.0 GB disk will not be written to until the first (1.1 GB) disk

is full. Extending a simple volume so that it includes more than one physical disk automatically makes it become a spanned volume. Figure 7-5 depicts a spanned volume. The process involved in creating a spanned volume is covered in Hands-on Project 7-8.

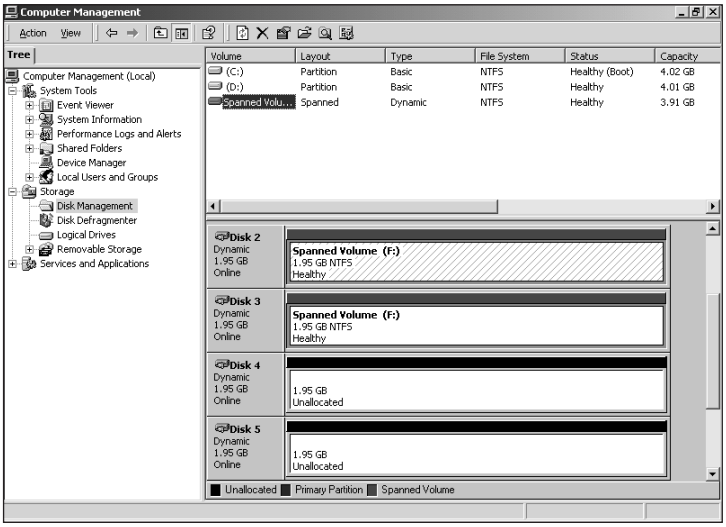

Figure 7-5 A spanned volume

Striped Volumes

Striped volumes are much like spanned volumes, with the only difference being that data are written to all of the disks in the volume in succession. This capability gives a striped volume a performance edge over a spanned volume. The data are written in chunks of 64 KB at a time, called the stripe. This stripe is then written to a disk, the next stripe is written to the next disk, and so on.

Imagine, for example, that you created the striped volume shown in Figure 7-6. The data will be written in 64 KB stripes to disk 2, then disk 3, then disk 4, and then disk 2 again. This process repeats until all data have been written to the disks.

Striped volumes offer a great increase in performance because the controllers can write to multiple disks at the same time. Therefore, instead of writing to disk 2 first, then to disk 3, and then to disk 4, the data are written to disk 2, disk 3, and disk 4 at the same time. You will especially notice a difference in performance on SCSI-based controllers and disks. The process involved in creating a striped volume is outlined in Hands-on Project 7-9.

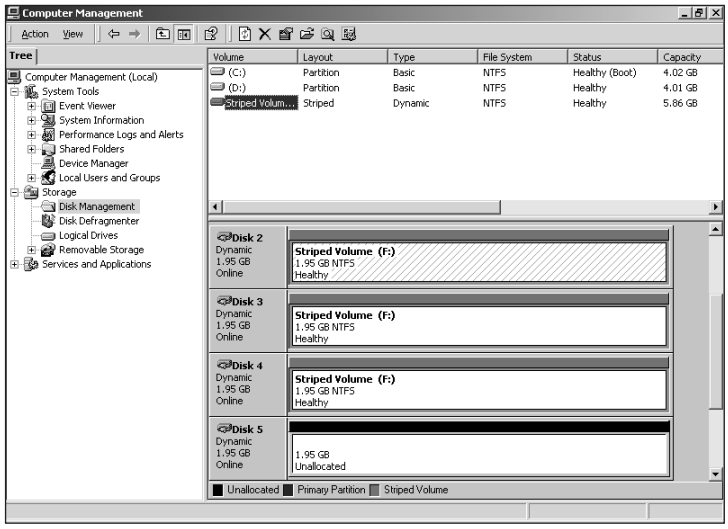

Figure 7-6 A striped volume

Fault-Tolerant Volumes

To most organizations, nothing is more important than their data. Many organizations today would not be able to function without access to their data. Imagine what would happen in your organization if the data stored on the servers suddenly became inaccessible. Unfortunately, not many users would be able to do their job using the pen-and-paper method. For this reason, most servers use some sort of fault tolerance to ensure that their data remain available.

Do not, however, assume that you do not need to back up your data because your data are stored on fault-tolerant volumes. Fault tolerance means just that—tolerant of faults. It is not a guaranteed storage method. No matter how advanced your fault-tolerance system is, do not stop performing regular tape backups on your data.

Most fault-tolerant systems fall under the RAID umbrella. RAID (redundant array of independent disks) is a set of guidelines that defines how disks are used for creating volumes. Each RAID configuration is assigned a level number, usually from 0 to 5 (although other, more advanced RAID levels exist as well). The main RAID levels are as follows:

- *RAID 0*—This sort of spanned volume provides no fault tolerance but is the fastest and most efficient RAID level.
- *RAID 1*—Also known as disk mirroring (or duplexing), this fault-tolerant configuration simply writes data to two different disks at the same time. Thus one of the disks can fail without incurring a loss of data. With disk mirroring, the mirrored disks use the same disk controller; with disk duplexing, the mirrored disks use different disk controllers. Disk duplexing allows for both controller failure and disk failure to occur without data loss.

- *RAID 2*—This scheme uses hamming error correction codes and is intended for use with drives that do not have built-in error detection. All modern SCSI disks have error detection/correction; therefore, this method is rarely used today.
- *RAID 3*—The data are striped between all disks, called a *stripe set*, and the parity is stored on a single-disk. The problem with this method is the amount of overhead required to recreate a failed disk if the parity disk fails. Striping is done at the byte level.
- *RAID 4*—The data are striped between all disks and the parity is stored on a single disk. The problem with this method is the amount of overhead required to recreate a failed disk if the parity disk fails. Striping is done at the block level.
- *RAID 5*—RAID5 is the most popular fault-tolerant system today. All data are striped between all disks and the parity is stored on each disk in succession, called a stripe set with parity. This method balances fault tolerance and performance better than the other RAID levels.

Windows 2000 supports RAID levels 0, 1, and 5 with striped volumes, mirrored volumes, and RAID 5 volumes, respectively. Although Windows NT 2000 are some of the only operating systems that support software RAID 5 (both Windows and NetWare support mirroring and duplexing), most administrators would not use software RAID. The reason for this reluctance is simple: software-based RAID is extremely resource-intensive, and most organizations would rather spend the money on hardware RAID than allow their servers to be negatively affected by performing software RAID.

Mirrored Volumes

Mirroring creates two volumes and writes the same information to both at the same time. If you created a 4 GB mirrored volume, for example, then two 4 GB disks would be needed. One would be the primary disk (such as C:) and the other would be the secondary disk (known as C: prime or C:'). **Mirrored volumes** require two units of storage for every usable unit of storage.

Mirroring disks is the easiest fault-tolerant configuration to set up that is available in Windows 2000. Unfortunately, this technique is also the most expensive method because of lost disk space. To create a mirrored volume, you need two disks with an equal amount of free space available on them (creating a mirrored volume with Windows 2000 is outlined in Hands-on Project 7-10, and recovering from a failed mirrored volume is covered in Hands-on Project 7-12). Figure 7-7 depicts a mirrored volume.

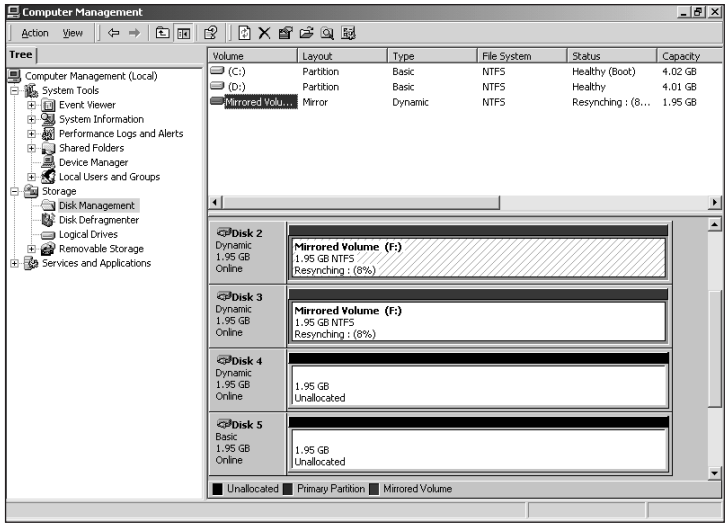

Figure 7-7 A mirrored volume

Another common mirroring technique, known as duplexing, creates a **duplexed volume**. A duplexed volume is essentially the same as a mirrored volume, with the only difference being the controllers to which the disks are connected. In disk mirroring, both mirrored disks are controlled by a single disk controller (either IDE or SCSI). Consequently, with a single disk failure the data would still be available and online. If a controller failure occurs, however, neither mirror disk would be available and the data would be offline. Chances are that the data would still be present on the disks, but you would have no way of accessing that information until you replaced the controller. With disk duplexing, each disk is controlled by its own controller. This technique allows the data to remain online even if a single controller fails.

RAID 5 Volumes

A RAID 5 volume is currently the most popular fault-tolerant method. Under Windows 2000, it consists of 3 to 32 disks. These disks become a single volume. With RAID 5 volumes, the data are divided into stripes, which are then written to the disk in order (disk 1, then disk 2, then disk 3, and so on). What makes this type of volume different from a striped volume, and fault-tolerant, is parity. Parity is simply a mathematical calculation that combines the data on all disks. If one disk fails, the lost data can be recovered from the parity information. For this reason, RAID 5 volumes can survive a single disk failure only. If more than one disk fails, you must replace the failed disks, recreate the volume, and recover the data from a backup. A RAID 5 volume is shown in Figure 7-8 and its creation is outlined in Hands-on Exercise 7-11. Hands-on Project 7-13 explains the steps involved in recovering from a RAID 5 volume failure.

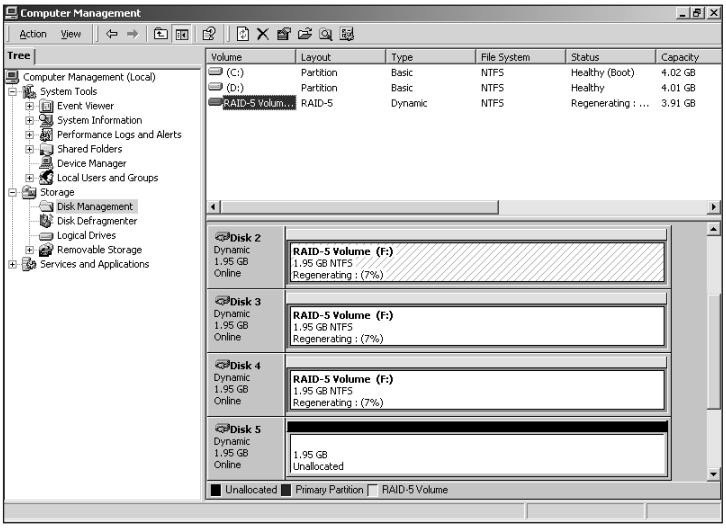

Figure 7-8 A RAID 5 volume

7

Applying User Quotas

One of the features that most network operating systems (such as UNIX and NetWare) have included for years is the ability to limit the amount of disk space on a volume to which a user has access, called a **quota**. Quotas have been lacking in Windows NT since its inception, and Windows NT administrators around the world have been asking for—even demanding—this feature for years. Windows 2000, in addition to providing dynamic disks and NTFS, finally brings this important feature to the Windows world.

Why Use Disk Quotas?

Why would you need disk quotas when disks are so inexpensive? The reasons are simple. You would normally put IDE disks in a desktop system. IDE drives are relatively inexpensive. SCSI disks, especially the high-end ones, remain relatively expensive, however. In small organizations, 30 GB of storage space goes a long way. With large organizations, however, disk space starts to number in the terabytes.

Most users assume that there is no limit when it comes to disk space. Many keep every e-mail, document, and file they've ever received. When the desktop system runs out of disk space, users may resort to copying their data to the server. Once the data are on the server, users assume a problem no longer exists. This practice is problematic for the system administrator, who needs to maintain the server in a stable and efficient manner.

Disk quotas allow you to limit the amount of disk space to which a user has access on a specific volume. They also provide the capability to monitor and control the disk space that these users are using. For disk quotas to be implemented successfully, the partition or volume must be formatted with the NTFS file system under Windows 2000.

A disk or volume that is formatted as NTFS with Windows NT 4.0 will not support quotas, because the version of NTFS that ships with Windows NT is not quota-aware. Windows 2000 NTFS is backward-compatible with Windows NT. For the reverse to be true, you must install Service Pack 4 or higher on your Windows NT 4.0 Servers. Once you have formatted the partition or volume using Windows 2000 NTFS, you can set quotas by accessing the Quota tab of the volume's Properties page, as shown in Figure 7-9. Table 7-2 lists the options and functions on the Quota tab.

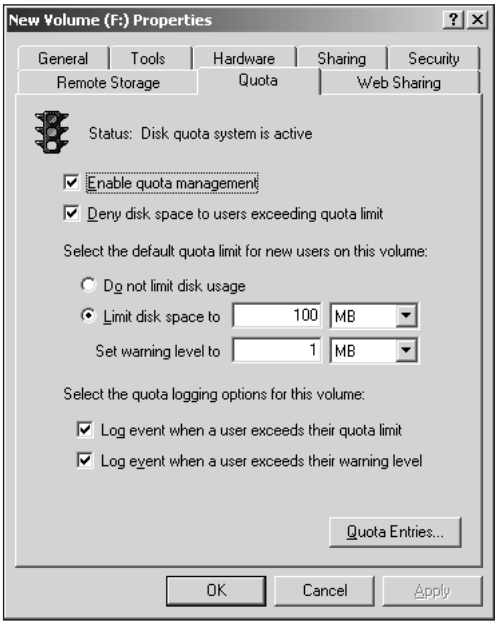

Figure 7-9 Enabling disk quotas

Any users who have written to a volume before you enable quotas will not have quotas assigned to them unless you manually assign one to them through the Quota Entries application.

Once quotas have been enabled for a specific partition or volume, you can monitor the quota usage by clicking the Quota Entries button on the Quota tab of the partition or volume's Properties dialog box. This action will launch the Quota Entries for New Volume application, as shown in Figure 7-10.

Table 7-2 Options available on the Quota tab and their tasks

Option	Task
Enable quota management	This option turns quota management on for the partition or volume. No quotas are monitored until this option is enabled.
Deny disk space to users exceeding quota limit	Once a user has reached his or her limit, Windows 2000 will not allow the user to write any more information to the volume. The user will receive an error message stating that the user is out of disk space.
Do not limit disk usage	This option tells Windows 2000 not to limit disk usage for users.
Limit disk space to	This amount is the maximum disk space that users are allowed to use on the partition or volume. The user will be denied write access to this volume once he or she has reached this limit if the "Deny disk space to users exceeding quota limit" option is enabled.
Set warning level to	When the user passes this storage level, an event will be logged stating that the user is nearing the limit.
Quota Entries	This button launches the Quota Entries application, which allows you to monitor quota usage for each user and to customize the quotas for individual users.

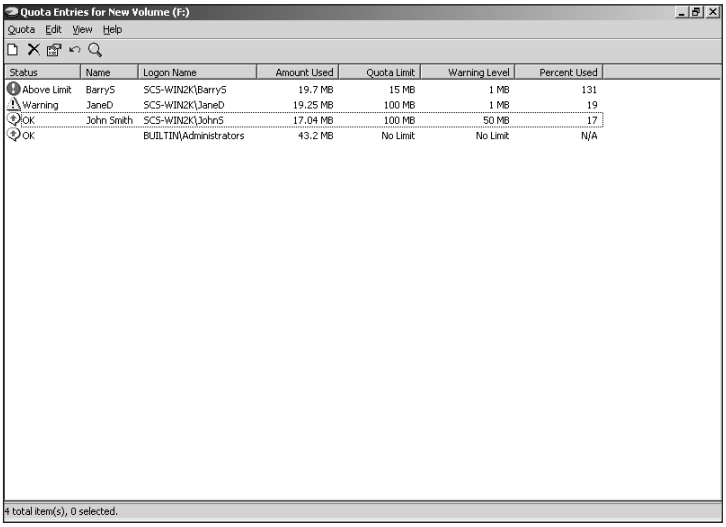

Figure 7-10 Viewing the disk space used by individual users

Once users have accessed and written data to the partition or volume, they will appear in the Quota Entries for New Volume application. Any users who accessed the volume before quotas were enabled will not have any limits assigned to them (see the Administrator user in Figure 7-10).

If you want to change the quota limits assigned to a specific user, you can simply double-click it and reset the quota limits and warning level for that user, as shown in Figure 7-11.

You can also select a number of users by highlighting them and holding down the Ctrl key, and then choosing the Properties option from the Quota menu.

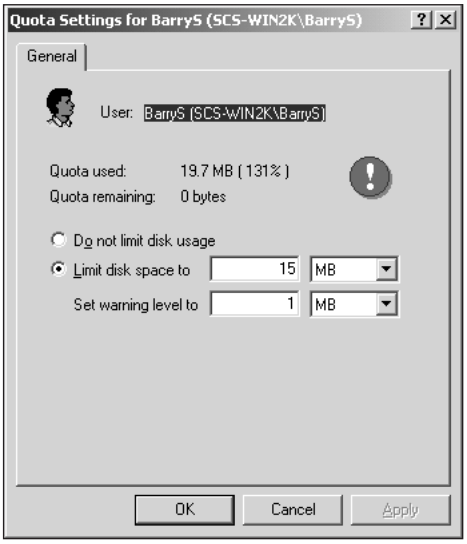

Figure 7-11 Modifying the quota properties for a user

Using this tool, you can also add users who have not accessed the volume via the following method:

1. Choose the New Quota Entry option from the Quota menu.
2. Select the desired user or users in the Select Users dialog box, and click Add.
3. Click OK.
4. Assign the disk limit and warning level for this user or users, and click OK.

ARCHIVING DATA

All of these updated and new features of Windows 2000 should not replace a good, old-fashioned backup. Although the new volumes help in the recovery of lost data, they do not replace the ability to recover a lost copy of a file from a secondary source, such as a tape or remote system.

Four different types of backup exist, as the following list shows. For these backup types to work properly, each file is given an archive bit. The **archive bit** denotes whether the file has been modified, thereby allowing the backup program to determine which files need to be backed up.

- **Copy backup** — A copy backup simply copies all files to the backup media without modifying the state of the archive bit.

- **Differential backup** — A differential backup backs up all information that has been modified since the last full backup. The archive bit is not reset.
- **Full (normal) backup** — A full (normal) backup simply backs up all files on the desired disks and resets the archive bit.
- **Incremental backup** — An incremental backup backs up all information that has been modified since the last backup. The archive bit is reset.

Windows 2000 includes a new version of NTBACKUP, the built-in backup and restore utility, shown in Figure 7-12.

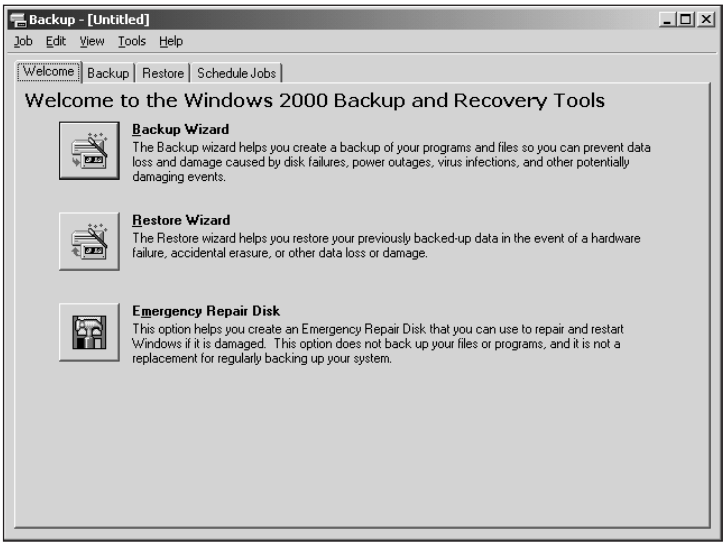

Figure 7-12 The built-in Windows 2000 Backup program

Backup Methods

Three types of backup methods exist: online, offline, and near-line. Each method has its own pros and cons, as described in the following sections.

Online

An **online backup** is simply a method of backing up the data so that the information is available and online at any point in time. Most common online backups copy the data over a network to a remote disk, which resides on a remote server. If the disk on the server fails, you can access the data from the remote system. Although an online backup is a very good way of ensuring that the data are available, it is not a common method for backing up, mostly because of the cost involved in setting up such a system.

Offline

An **offline backup** is the most commonly used method of backing up data. It involves making a copy of the data and placing it on a tape so that it can be recovered at a later date. Most organizations use this method because it is the cheapest and safest way of backing up data. Its main disadvantage is that you must retrieve the tape and restore the data if a failure occurs.

Near-line

A **near-line backup** is becoming increasingly more common with the advent of writable and rewritable CD-ROM drives. The data are still available, albeit on a slower system. This method is very effective for systems that have infrequently used data that must remain accessible at all times.

CHAPTER SUMMARY

- This chapter discussed the two disk types that are available in Windows 2000: basic and dynamic.
- It also considered the steps involved in maintaining the various types of volumes and partitions that Windows 2000 supports. The Hands-on Projects that follow this chapter, provided you a good introduction to the types of volumes available, as well as the steps for their creation and management.
- Implementing quotas using Windows 2000's new quota feature was also discussed.
- Finally, the chapter explained the methods available in Windows 2000 for backing up data.

KEY TERMS

archive bit — An attribute that allows the backup program to decide which files have been modified. Any file that has the archive bit set has been modified.

basic disk — A disk that has been partitioned and formatted using Windows NT 4.0. Basic disks can support primary and extended partitions as well as logical disks.

copy backup — A backup method that copies the data to the backup media without changing the archive bit of the files.

differential backup — A backup method that backs up all data added or modified since the last full backup. This method resets the archive bit.

duplexed volume — A volume that uses two disks on two separate controllers. The data are written to both disks at the same time.

dynamic disk — A new type of disk introduced with Windows 2000. It allows for an unlimited number of volumes to be created on a single disk.

full backup — A backup method that completely backs up the data to the backup media and resets the archive bit.

incremental backup — A type of backup that will back up all data added or modified since the last backup without resetting the archive bit.

mirrored volume — A volume on a dynamic disk that uses two disks and writes the same data to both of them.

near-line backup — Data are migrated from the hard disk to a slower, but easily accessible media such as CD-ROMs. This backup technique allows the data to be accessible without using up disk space.

offline backup — A backup method in which data are copied to removable media, such as a tape.

online backup — A backup technique in which a copy of the data is maintained at all times on a separate and remote system.

quota — The amount of disk space to which a user has access on a quota-enabled volume.

striped volume — Same as a stripe set, but for dynamic disks.

Review Questions

1. What is the maximum number of partitions that can be created on a basic disk?
   a. 1
   b. 2
   c. 3
   d. 4
2. Dynamic disks are created as basic disks and then upgraded. True or False?
3. Once a disk has been upgraded to a dynamic disk, it can no longer become a basic disk. True or False?
4. Which of the following partition types can contain logical disks?
   a. Primary
   b. Secondary
   c. Extended
   d. Logical
5. Any volume or partition that is formatted using NTFS can be extended. True or False?
6. A volume that exists on only a single dynamic disk is known as a:
   a. Simple volume.
   b. Spanned volume.
   c. Striped volume.
   d. Mirrored volume.
   e. RAID 5 volume.

7. A volume that uses striping as well as parity is known as a:
   a. Simple volume.
   b. Spanned volume.
   c. Striped volume.
   d. Mirrored volume.
   e. RAID 5 volume.
8. A volume that uses striping for improved performance but does not include fault tolerance is known as a:
   a. Simple volume.
   b. Spanned volume.
   c. Striped volume.
   d. Mirrored volume.
   e. RAID 5 volume.
9. When data are written to two disks at the same time, the process creates a _____ volume.
10. A volume that includes disk space on more than one physical disk is known as a:
    a. Simple volume.
    b. Spanned volume.
    c. Striped volume.
    d. Mirrored volume.
    e. RAID 5 volume.
11. What is the minimum number of disks in a striped volume?
    a. 1
    b. 2
    c. 3
    d. 4
12. What is the minimum number of disks in a RAID 5 volume?
    a. 1
    b. 2
    c. 3
    d. 4
13. Both basic and dynamic disks can support quotas as long as they are formatted using NTFS and Windows 2000. True or False?
14. "Mirrored volumes" and "duplexed volumes" are interchangeable terms. True or False?
15. You can assign different quotas for each user who accesses an NTFS volume. True or False?

16. Which Windows 2000 administration tool would you use to manage your partitions and volumes?
    a. Disk Administrator
    b. Disk Manager
    c. Volume Manager
    d. Computer Management
17. What is the maximum number of disks that can be supported by striped volumes?
    a. 24
    b. 32
    c. 48
    d. 64
18. What is the maximum number of disks that can be supported by RAID 5 volumes?
    a. 24
    b. 32
    c. 48
    d. 64
19. You can have as many as four extended partitions in a basic disk. True or False?
20. Mirrored volumes can be converted to RAID 5 volumes by adding an extra disk and choosing the Upgrade To RAID 5 option. True or False?

HANDS-ON PROJECTS

Project 7-1

Before Windows 2000 will recognize a new disk, you must allow the operating system to write a signature to the disk.

Note: The disk used in this exercise must be formatted with NTFS.

To write a signature to a new disk:

1. Click **Start**, **Programs**, **Administrative Tools**, **Computer Management**.
2. Highlight the **Disk Management** option in the left pane of the Computer Management tool.
3. Highlight an unallocated basic disk in the lower-right pane and right-click it.
4. Choose the **Write signature** option from the menu.

Project 7-2

When creating a primary partition on a basic disk in Windows 2000, you need to follow the steps described here.

To create a primary partition:

1. Click **Start**, **Programs**, **Administrative Tools**, **Computer Management**.
2. Highlight the **Disk Management** option in the left pane of the Computer Management tool.
3. Highlight an unallocated basic disk in the bottom-right pane and right-click it.
4. Choose the **Create Partition** option from the menu. The Create Partition Wizard will launch. The screen shown in Figure 7-13 appears. Click **Next**.

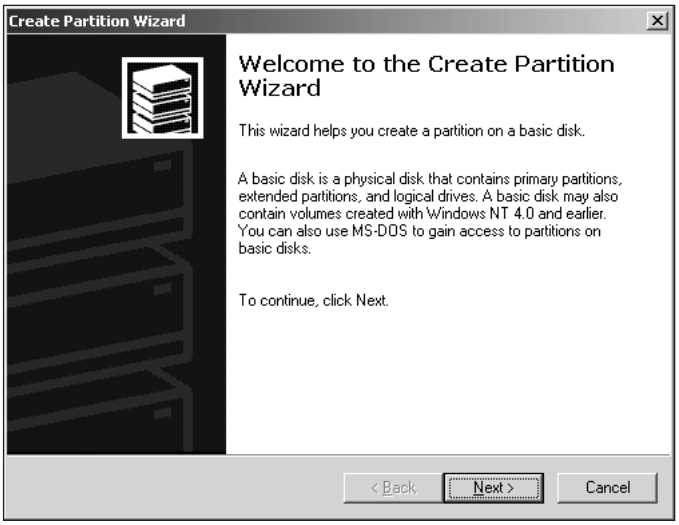

Figure 7-13 Create Partition Wizard

5. Make sure that **Primary partition** is selected, and click **Next**.
6. Enter the amount of disk space to be used for the partition, as shown in Figure 7-14, and click **Next**.

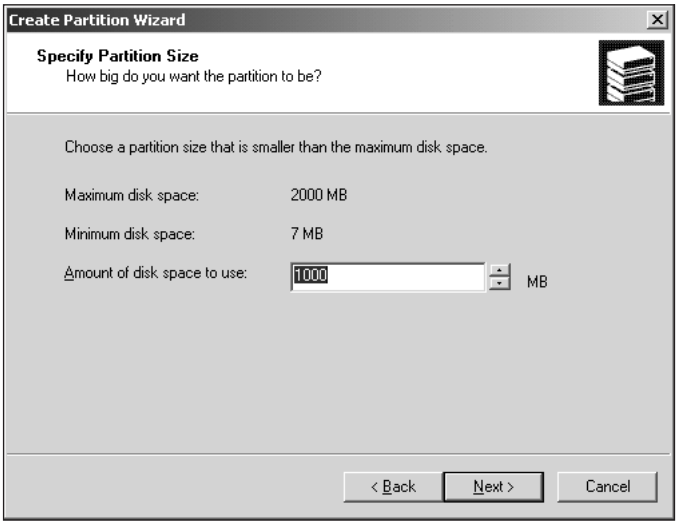

Figure 7-14 Specify Partition Size window

7. Choose either to assign a drive letter to this partition, to mount this volume to a folder that supports drive paths, or to not assign a drive letter, as shown in Figure 7-15, and click **Next**.

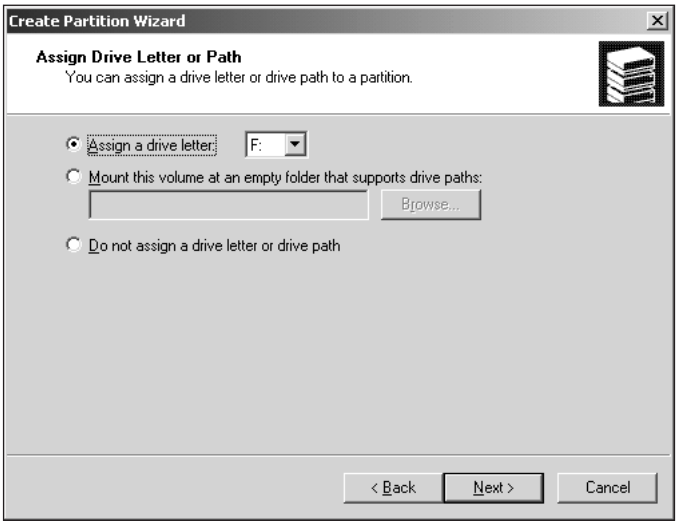

Figure 7-15 Assign Drive Letter or Path window

8. Choose either to leave the partition unformatted or to format it in one of the supported file systems. Refer to Figure 7-16. The file systems supported by primary partitions are FAT, FAT32, and NTFS. Click **Next**.

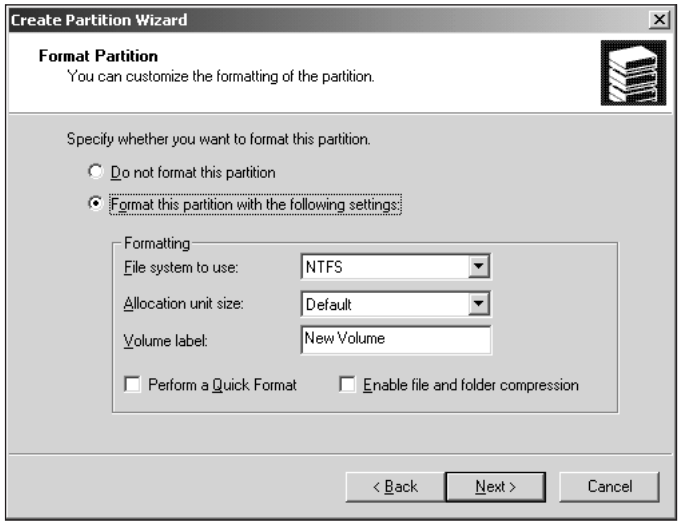

Figure 7-16 Format Partition window

9. Confirm the settings in the wizard, and click **Finish** to create the partition.

Project 7-3

Before logical disks can be created on a basic disk, you must create an extended partition. Only one extended partition is permitted on a single basic disk.

To create an extended partition:

1. Click **Start**, **Programs**, **Administrative Tools**, **Computer Management**.
2. Highlight the **Disk Management** option in the left pane of the Computer Management tool.
3. Highlight an unallocated basic disk in the lower-right pane and right-click it.
4. Choose the **Create Partition** option from the menu. The Create Partition Wizard will launch. Click **Next**.
5. Make sure that **Extended partition** is selected, and click **Next**.
6. Specify the size of the partition. Click **Next**.
7. Click **Finish** to create the extended partition.

Project 7-4

This exercise illustrates the steps involved in creating a logical drive.

To create a logical drive:

1. Highlight the extended partition in the lower-right pane and right-click it.
2. Choose the **Create Logical Drive** option from the drop-down menu. The Create Partition Wizard will launch. Click **Next**.

3. Make sure that **Logical drive** is selected, as shown in Figure 7-17, and click **Next**.

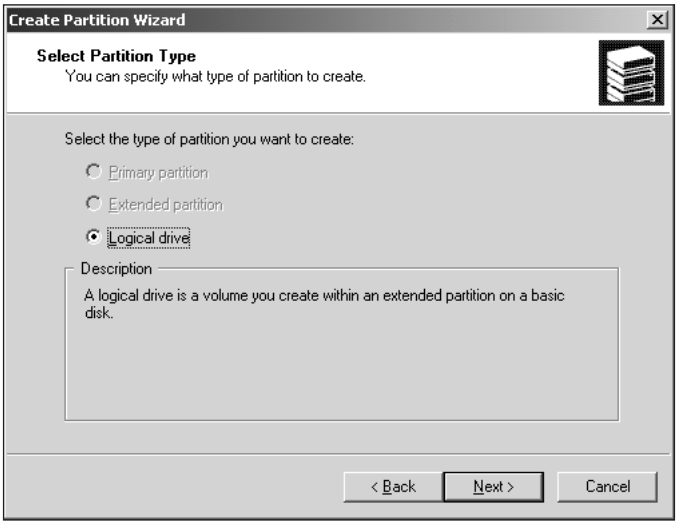

Figure 7-17 Select Partition Type window

4. Enter the amount of disk space to be used for the partition, and click **Next**.
5. Choose either to assign a drive letter to this partition, to mount this volume to a folder that supports drive paths, or to not assign a drive letter, and click **Next**.
6. Choose either to leave the partition unformatted or to format it in one of the supported file systems. The file systems supported by logical disks are FAT, FAT32, and NTFS. Click **Next**.
7. Confirm the settings in the wizard, and click **Finish** to create the partition.

Project 7-5

Before you can use some of the new disk features of Windows 2000, you must upgrade the basic disks to dynamic ones.

To convert a basic disk to a dynamic disk:

1. Click **Start**, **Programs**, **Administrative Tools**, **Computer Management**.
2. Highlight the **Disk Management** option in the left pane of the Computer Management tool.
3. Highlight a basic disk in the lower-right pane and right-click it.
4. Choose the **Upgrade to dynamic disk** option. The window shown in Figure 7-18 will appear.

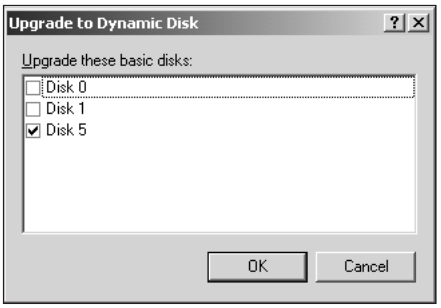

Figure 7-18 Upgrade to Dynamic Disk Wizard

5. Check the disks that you would like to upgrade, and click **OK**. The basic disk will be initialized and will become a dynamic disk shortly.

Note: A dialog box confirming the upgrade may appear. If it does, click OK.

Project 7-6

The most basic volume that can be created on a Windows 2000 dynamic disk is known as a simple volume. A simple volume contains space from only a single disk:

To create a simple volume:

1. Click **Start**, **Programs**, **Administrative Tools**, **Computer Management**.
2. Highlight the **Disk Management** option in the left pane of the Computer Management tool.
3. Highlight an unallocated dynamic disk in the lower-right pane and right-click it.
4. Choose the **Create volume** option from the drop-down menu. The Create Volume Wizard will launch.
5. Click **Next**.
6. Ensure that **Simple volume** is selected, and click **Next**. See Figure 7-19.
7. Choose the amount of disk space to be used in the simple volume, and click **Next**.
8. Choose either to assign a drive letter to this volume, to mount this volume to a folder that supports drive paths, or to not assign a drive letter, and click **Next**.
9. Choose either to leave the volume unformatted or to format it in one of the supported file systems. The file systems supported by simple volumes are FAT, FAT32, and NTFS. Click **Next**.
10. Confirm the settings in the wizard, and click **Finish** to create the volume.

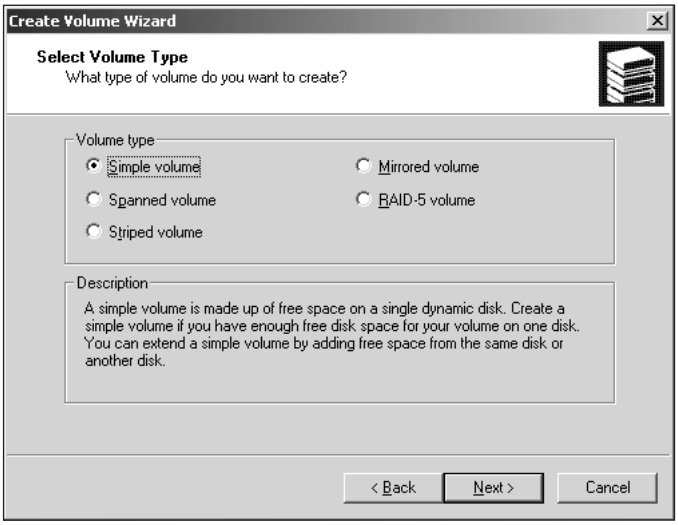

Figure 7-19 Select Volume Type window for dynamic disks

Project 7-7

Once a volume has been created on a dynamic disk and formatted using Windows 2000 NTFS, it can be extended. Extending a volume is the act of increasing the size of the volume by allocating unused free space from the disk to the volume.

To extend a volume:

1. Click **Start**, **Programs**, **Administrative Tools**, **Computer Management**.
2. Highlight the **Disk Management** option in the left pane of the Computer Management tool.
3. Highlight a simple volume in the lower-right pane and right-click it.
4. Choose the **Extend volume** option from the menu. The **Extend Volume Wizard** will launch.
5. Click **Next**.
6. Choose the amount of disk space by which to extend the volume, and click **Next**. Remember, if you extend a simple volume beyond the physical boundaries of a single disk, it will become a spanned volume.
7. Click **Finish** to extend the partition.

Project 7-8

Spanned volumes are similar to simple volumes, but differ in that they contain space from more than one physical disk. There is no limit with dynamic disks as to the number of disks that can be used in the spanned volume.

To create a spanned volume:

1. Click **Start**, **Programs**, **Administrative Tools**, **Computer Management**.
2. Highlight the **Disk Management** option in the left pane of the Computer Management tool.
3. Highlight an unallocated dynamic disk in the lower-right pane and right-click it.
4. Choose the **Create volume** option from the menu. The Create Volume Wizard will launch.
5. Click **Next**.
6. Ensure that **Spanned volume** is selected, and click **Next**.
7. Choose which disks are to be used for the spanned volume and the amount of disk space to be used on each disk, and click **Next**.
8. Choose either to assign a drive letter to this volume, to mount this volume to a folder that supports drive paths, or to not assign a drive letter, and click **Next**.
9. Choose either to leave the volume unformatted or to format it in one of the supported file systems. The file systems supported by spanned volumes are FAT32 and NTFS. Click **Next**.
10. Confirm the settings in the wizard, and click **Finish** to create the volume.

Project 7-9

A striped volume acts in much the same way as a spanned volume does, except that the data are written in stripes to all disks in rapid succession.

To create a striped volume:

1. Click **Start**, **Programs**, **Administrative Tools**, **Computer Management**.
2. Highlight the **Disk Management** option in the left pane of the Computer Management tool.
3. Highlight an unallocated dynamic disk in the lower-right pane and right-click it.
4. Choose the **Create volume** option from the drop-down menu. The Create Volume Wizard will launch.
5. Click **Next**.
6. Ensure that **Striped volume** is selected, and click **Next**.
7. Choose which disks are to be used for the striped volume and the amount of disk space to be used on each disk, and click **Next**.
8. Choose either to assign a drive letter to this volume, to mount this volume to a folder that supports drive paths, or to not assign a drive letter, and click **Next**.

9. Choose either to leave the volume unformatted or to format it in one of the supported file systems. The file systems supported by striped volumes are FAT32 and NTFS. Click **Next**.
10. Confirm the settings in the wizard, and click **Finish** to create the volume.

Project 7-10

Before you create a mirrored volume, you must have two disks with free space on them. The volume size will be limited by the smallest amount of disk space on the two disks.

To create a mirrored volume:

1. Click **Start**, **Programs**, **Administrative Tools**, **Computer Management**.
2. Highlight the **Disk Management** option in the left pane of the Computer Management tool.
3. Highlight an unallocated dynamic disk in the lower-right pane and right-click it.
4. Choose the **Create volume** option from the menu. The Create Volume Wizard will launch.
5. Click **Next**.
6. Ensure that **Mirrored volume** is selected, and click the **Next** button.
7. Choose which disks are to be used for the mirrored volume and the amount of disk space to be used on each disk, and click **Next**.
8. Choose either to assign a drive letter to this volume, to mount this volume to a folder that supports drive paths, or to not assign a drive letter, and click **Next**.
9. Choose either to leave the volume unformatted or to format it in one of the supported file systems. The file systems supported by mirrored volumes are FAT, FAT32, and NTFS. Click **Next**.
10. Confirm the settings in the wizard, and click **Finish** to create the volume.

Project 7-11

At least three disks are required before you can create a RAID 5 volume. These disks must be physically different.

To create a RAID 5 volume:

1. Click **Start**, **Programs**, **Administrative Tools**, **Computer Management**.
2. Highlight the **Disk Management** option in the left pane of the Computer Management tool.
3. Highlight an unallocated dynamic disk in the lower-right pane and right-click it.
4. Choose the **Create volume** option from the menu. The Create Volume Wizard will launch.
5. Click **Next**.
6. Ensure that **RAID 5 volume** is selected, and click **Next**.

7. Choose which disks are to be used for the RAID 5 volume (with a minimum of three) and the amount of disk space to be used on each disk, and click **Next**.
8. Choose either to assign a drive letter to this volume, to mount this volume to a folder that supports drive paths, or to not assign a drive letter, and click **Next**.
9. Choose either to leave the volume unformatted or to format it in one of the supported file systems. The file systems supported by RAID 5 volumes are FAT, FAT32, and NTFS. Click **Next**.
10. Confirm the settings in the wizard, and click **Finish** to create the volume.

Project 7-12

This exercise illustrates the steps involved in recovering from a failed mirrored disk.

To repair a failed mirrored volume:

1. When a disk in a mirrored volume fails, the error message shown in Figure 7-20 will be displayed. The Disk Management administration tool will notify you as to which disk has failed. You will need to replace this disk before continuing. See Figure 7-21.

Figure 7-20 A failed disk error message

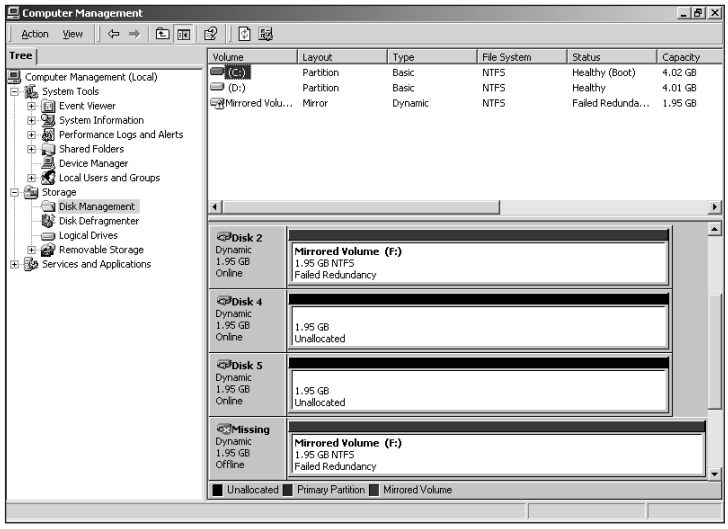

Figure 7-21 A failed mirrored volume member

If your disk array supports hot-swappable disks, then you can replace the failed disk without rebooting the system. Otherwise, a reboot is required before the failed mirrored volume is regenerated.

2. After the disk has been replaced, Windows 2000 will continue to see it as being offline. You will need to reactivate it. To do so, right-click the disk and choose the **Reactivate disk** option from the menu.
3. Windows 2000 will bring the new disk online and automatically regenerate the failed mirrored volume, if possible. If the volume is not automatically regenerated, right-click the failed volume in the upper-right pane and choose either the **Repair Volume**, **Resynchronize volume**, or **Reactivate volume** option.

Project 7-13

This exercise illustrates the steps involved in recovering from a failed RAID 5 disk.

To repair a failed RAID 5 volume:

1. When a disk in a RAID 5 volume fails, an error message will be displayed to notify you of the failure. The Disk Management administration tool will notify you as to which disk has failed. You will need to replace this disk before continuing. See Figure 7-22.

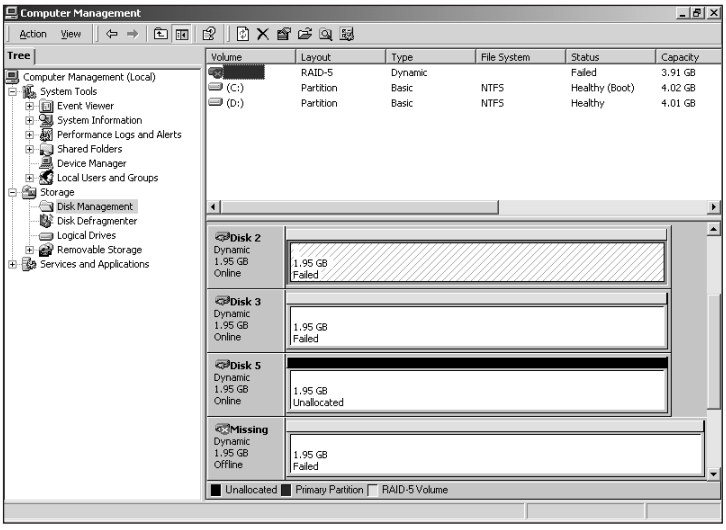

Figure 7-22 A failed RAID 5 volume member

If your disk array supports hot-swappable disks, then you can replace the failed disk without rebooting the system. Otherwise, a reboot is required before the failed mirrored volume is regenerated.

2. After the disk has been replaced, Windows 2000 will continue to see it as being offline. You will need to reactivate it. To do so, right-click the disk and choose the **Reactivate disk** option from the menu.
3. Windows 2000 will bring the new disk online and automatically regenerate the failed RAID 5 volume, if possible. If the volume is not automatically regenerated, right-click the failed volume in the top-right pane and choose either the **Repair Volume** or **Reactivate volume** option.

CASE PROJECTS

1. You are adding a drive array to an existing Windows 2000 system. You would like to maximize the performance of these new disks while maintaining a single volume. You do not require any fault tolerance. Which volume type would you create?
2. You are installing Windows 2000 on a system that has five disks available to it. You would like to create a fault-tolerant system that will give you the largest amount of free space possible. Which volume type would you create?
3. You are trying to extend an existing volume that is formatted with the FAT file system on your Windows 2000 system, but your attempt is unsuccessful. Why?
4. You would like to protect your Windows 2000 system from a single disk or disk controller failure. Which volume type would you implement?